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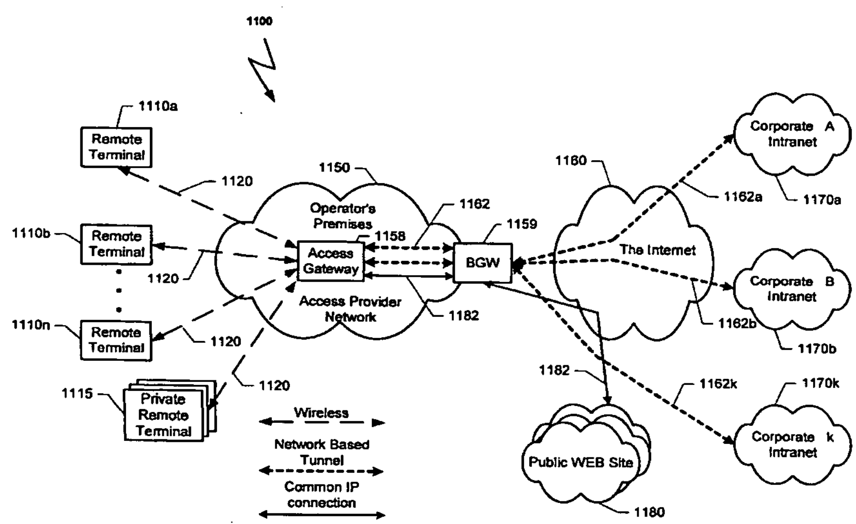

(57) **Abstract:** Traffic passing between remote terminals (1110) and corporate intranets (1170) through an access server provider network (1150) can encounter security and addressing problems. Intercepting and manipulating this traffic can overcome these, as well as other problems. For such traffic that is being transported over a plurality of Network Based Tunnels (NBT), this manipulation can be performed by manipulation equipment that may reside in the access server provider's network between an Access Gateway (1158)) and a Border Gateway (1159). The manipulation equipment may manipulate received NBT packets by parsing the original packet that is encapsulated in the NBT packet, manipulating the original packet and reconstructing the NBT packet with the manipulated data of the original packet.

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METHOD AND SYSTEM FOR CONNECTING MANIPULATION EQUIPMENT BETWEEN OPERATOR'S PREMISES AND THE INTERNET

RELATED APPLICATIONS

This patent application claims the benefit of the filing date of United States Provisional Application for Patent having Serial Number 60/388,397 and having been filed on June 14, 2002.

FIELD OF THE INVENTION

The present invention relates to mobile data communication and, more particularly, to a system and method for connecting Manipulation Equipment (MEq) in a Wireless Operator's Premises that supports Enterprise Virtual Private Networks (VPN).

BACKGROUND

Conventionally, companies have networked geographically dispersed intra-corporation networks together through the use of private lines. This technique allowed for the formation of a network system that was isolated from external networks and thus, had some level of assurance that the network would be secure. However, when intra-corporation communication is conducted over the Internet, thereby taking advantage of the low cost associated with such connectivity, the enterprise communication is done through the use of a Virtual Private Network (VPN). The use of a VPN for such a solution results in virtually building private networks through the Internet by using the Internet Protocol (IP) facilities provided by IP networks and the facilities of lower layer protocols below the IP. This art enables building a safe network that is isolated from

external networks and can provide quality assurance service of any level, even through the Internet.

Today, the workforce continues to migrate towards mobility and thus, the requirements for employees to have remote data access generates an increasing need for communication through Mobile VPNs (MVPN) that are spread over wire line networks and wireless data networks. A MVPN may use a combination of data packets, radio protocols on the mobile side (dynamic side) and tunneling protocols on the plane side (fix side, static side). A static tunnel between the wireless operator's premises and the intranet of a corporation, connecting through the Internet Service Provider (ISP), is called a Network Based Tunnel (NBT). An exemplary NBT may be a "Compulsory Tunnel" (CT). Throughout this description, the terms Network Based Tunnel and Compulsory Tunnel may be used interchangeably and/or have the same meaning. An exemplary protocol for packet communication over wireless data networks is the General Packet Radio Service (GPRS). Other wireless protocols may include, but are not limited to, HDR (High Data Rate), CDPD (Cellular Digital Packet Data), etc., as well as others not listed.

An NBT may be used by multiple peers of the same corporation and may be active even without any current transportation. The NBTs are based on protocols such as, but not limited to, the IPSec, LSP/IPSec, L2TP, GRE, IEEE 802.1Q (VLAN Tagging, or VLAN TAG, both terms are used interchangeably herein), IP over IP protocols, as well as other protocols not listed. The wireless operator has an Access Gateway (AGW), which converts NBT traffic coming through the Internet, or over a direct connection from the corporation's intranet, via a Border Gateway (BGW), into an appropriate wireless protocol and vice-versa. One example of an Access Gateway is the Gateway GPRS Support Node (GGSN). Another example of an Access Gateway is a Packet Data Serving Node (PDSN) such as those used in CDMA2000 Radio Access Network (RAN).

In intra-corporation networks, private IP addresses are often used. IP addresses are divided into public IP addresses and private IP addresses. Public IP addresses are globally defined unique addresses, whereas private IP addresses can be freely defined by a corporation. Thus, it is desirable for private IP addresses to be used when corporations

use VPN service. If a plurality of VPNs are employed, and private IP addresses are used over the VPNs, it is possible that a private IP address used in one VPN is also used in another VPN during the same time over the wireless operator network.

To improve services, an operator may want to add Manipulation Equipment (MEq) that operates to interrupt the communication between a remote client and its final destination, and then perform some manipulation on the data. An exemplary MEq may be a personalization server that operates to add personal banners to the communication being directed towards the remote client. Another exemplary MEq may be a front-end content server such as the MS Exchange Server. Other MEq may operate to improve the speed of the communication and reduce the volume of data over the wireless lines. Generally, the MEq is located between the Access Gateway and the Border Gateway or Router. An MEq may manipulate the data in internal layers, such as: the Transport layer (TCP), in the application layer (HTTP, MAPI etc.) and in the content (html, gif etc.). Within the context of this description, the terms manipulation, optimization and acceleration may be used interchangeably and at times, may have the same meaning.

In the case of using a VPN, the communication between the Access Gateway and the Border Gateway is done through an NBT. Therefore there is a need to break the NBT at the input to the MEq and reconstruct (re-tunnel) the tunnel at the output of the MEq. Moreover, the tunnel between the operator's network and the corporation's intranet(s) may comprises a plurality of connections from a plurality of mobile peers, some of them may use the MEq and others may not. Furthermore, the communication from/to a client using the MEq may contain information that is not handled by the MEq. These are some of the difficulties that a system, which splits the NBT, needs to overcome in re re-constructing, or re-tunneling, the tunnel. In addition to these difficulties, the data that returns from the MEq may be different than the data that was sent to the MEq.

The transportation over the VPN may be protected by mechanisms such as Remote Authentication Dial In User Service (RADIUS) in the plane section. Another mechanism may be to encrypt the data flow. These methods operate to protect the confidentiality of the connection. The splitter system, which reads, processes and manipulates the transportation, needs to inter-operate with these methods.

Therefore there is a need for a system and a method for splitting a plurality of VPN tunnels, in between the Access Gateway in the operator's network and a plurality of corporate intranets over a data network (like the Internet or via private connection), decrypting the data, redirecting the data to a manipulation server, manipulating the data, receiving the manipulated data, encrypting the manipulated data and reconstructing the appropriate tunnels (re-tunneling) again.

SUMMARY OF THE INVENTION

The present invention provides a system and a method that enables manipulation of data in an Access Service Provider network. The manipulation is done while the data is transported over a plurality of Network Based Tunnels (NBT) between a remote client (for example a wireless client) and the intranet of the client's corporation. The system may reside in the Access Server Provider's network between the Access Gateway (AGW) and the Border Gateway (BGW). The present invention may manipulate transportation between a remote client and its corporate intranet by parsing the packet of the NBT, transferring the original packet, the packet that is encapsulated in the NBT packet, to the MEq, manipulating the original packet and reconstructing the NBT packet with the manipulated data. The present invention is operative in both directions.

Other features and advantages of the present invention will become apparent upon reading the following detailed description of the embodiments with the accompanying drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1a is a block diagram of general intra-corporation communication between remote peers and their corporate intranet.

Fig. 1b is a block diagram of intra-corporation communication between remote peers and their corporate intranet, while the Access Provider is using GPRS network.

Fig. 2 is a block diagram illustrating the employment of modification equipment within the network topology embodiment shown in Fig. 1a.

Fig. 3 is a block diagram of an exemplary MEq Farm 210 that could be employed in the exemplary embodiment illustrated in Fig. 2.

Fig. 4 is a block diagram illustrating another exemplary embodiment of an MEq Farm.

Figs. 5a and 5b are flow charts that illustrate an exemplary method that may be used by an IF Server Module (Fig. 3) for handling packets coming from an AGW (Fig. 2).

Figs. 6a and 6b are flow charts that illustrate an exemplary method that may be used by an IF Module (Fig. 3) for handling packets coming from a BGW (Fig. 2).

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, in which like numerals refer to like parts throughout the several views, exemplary embodiments of the present invention are described.

Fig. 1a is a block diagram of intra-corporation communication between mobile peers and their corporate intranet. A communication system **1100**, which uses tunnels between the Access Provider Network (APN) **1150** and the corporate intranet, has been selected as an exemplary environment that is suitable for implementing the present invention. The communications system **1100** may be a cellular data communication network, satellite networks, access networks, Internet Service Provider (ISP), or other type of network or communication system. Within the context of this description, the terms cellular, satellites, wireless, and ISP may be used interchangeably and at times, may have the same meaning.

A plurality of remote terminals, **1110a - 1110n**, are connected via data links **1120** to an Access Gateway (AGW) **1158** within the Access Provider Network **1150**. The connection between the remote terminals **1110a - 1110n** and the APN **1150** may be via intermediate nodes (such as a base station etc,) not shown in Fig. 1a. The remote terminals **1110a - 1110n** represent any devices that can communicate data over a data network using an Internet Protocol, including but not limited to: laptop computers, palm computers, cellular phones or the like. By way of example, Fig. 1a illustrates the use of

three terminals; however, those skilled in the art will realize that any number of terminals could be used in this system.

The AGW **1158** acts as an access gateway. It provides foreign agent support and packet transport for virtual private networking. It also acts as an Authentication, Authorization, and Accounting (AAA) agent for the remote client. AGW **1158** may be a Remote Access Server (RAS), GGSN or PDSN or any other similar node. The AGW **1158** is the gateway between the network system of the wireless operator and the external data network, which may be the Internet **1160** and/or the corporate intranets **1170** that may be connected directly to the operator's premises **1162k** or via the Internet **1160**. The AGW **1158** performs the following operations in the uplink direction:

(a) the AGW **1158** terminates the connection from remote terminals **1110** and initiates the setup of an NBT **1162** to the appropriate corporate intranet **1170a** - **1170k** through Border Gateway (BGW) **1159**;

(b) the AGW **1158** routes the appropriate packets received from a remote client to the appropriate NBT **1162** of his/her corporation;

(c) the AGW **1158** may send via the same NBT **1162**, packets of different users that belong to the same corporation.

The AGW **1158** performs the following operations in the downlink direction:

(a) the AGW **1158** terminates the NBT **1162** and forwards packets to the remote clients **1110a** - **1110n** and **1115**; and

(b) the AGW **1158** receives through the same tunnel **1162** packets with destination addresses of different remote clients **1110** of the same corporation.

By way of example, three corporate intranets **1170a** - **1170k** are illustrated, however, those skilled in the art will realize that any number of corporate intranets **1170** could be included.

From AGW **1158**, the traffic through the NBT **1162** is transferred via a Border Gateway (BGW) **1159** that routes each NBT to the appropriate corporate intranet **1170**. Within this description, the terms BGW and the Border Router may be used interchangeably.

Traffic from private remote user **1115** not belonging to any of the corporations or not intended for a corporate intranet, follows the path through the wireless connection **1120** to AGW **1158,** BGW **1159**, the Internet **1160** and finally to public web sites **1180** via common IP connections **1182** to its final destination and not via any of the NBT **1162.** The IP connection **1182** may include, but is not limited to, TCP, UDP and others.

Fig. 1b is a block diagram of intra-corporation communication between mobile peers and their corporation while the Access Provider is using a GPRS network. A cellular system **100** based on the GPRS protocol has been selected as an exemplary environment that is suitable for implementing an embodiment of the present invention. However, the present invention is not limited to any particular cellular communication system, but rather, any other communications system using tunnels may be employed. Such other communication systems include, but are not limited to, communication over: satellites networks, PSTN (Public Switched Telephone Network), ISDN (Integrated Services Digital Network) lines or the like.

A plurality of laptop computers (**110A5, 110C5, 110B2, 110B7** and **110A3)** are connected via cellular connections **120** to a plurality of Base Stations (BS) **130a - 130n**. The laptop computers **110** represent any portable devices that can communicate data over a wireless network using an Internet Protocol, such as but not limited to, palm computers, cellular phones or the like. By way of example, three laptop computers **110** are shown as connected to each **BS 130**, however, those skilled in the art will realize that any number of laptop computers **110** can be connected. Also, by way of example, two **BS 130** are connected to the operator's premises; however, those skilled in the art will realize than any number of BSs could be used. BS **130** may be connected via a VWB (Very Wide Bandwidth) connection **140** to the operator's premises **150**. The VWB connection may be a Frame Relay, ISDN, ATM, Fiber optic connection or any other appropriate connection.

The connection of the BS **130** to the operator premises **150** is terminated at System GPRS Support Node (SGSN) **152a** to **152k.** The SGSN is responsible for the mobility management; session management; authentication procedures; and routing the packets downlink to the appropriate BS **130** and sending the packets uplink via GTP

tunnels **154a** and/or **154k** to the appropriate Gateway GPRS Support Node (**GGSN**) **158**. GPRS Tunneling Protocol (**GTP**) tunnels run over IP-based Networks, in the wireless operator's premises between the SGSN **152** and the GGSN **158**. By way of example, two SGSNs **152** in the operator's premises are shown; however, those skilled in the art will realize that any number of SGSNs **152** can be utilized. Each SGSN **152** may be connected to more than one GGSN **158**, which may be located in another operator's premises (not shown).

The GGSN **158** is the Access Gateway between the GPRS Network System of the wireless operator and the external data network, which may be the Internet **160** and/or the corporate intranets **170** that may be connected directly to the operator's premises **150** (not shown in the drawing) or via the Internet **160**.

The GGSN **158** performs the following tasks in the uplink direction:

a) the GGSN terminates the GTP tunnels from SGSN **152** and initiates CTs **162** to the appropriate corporate intranet via Border Gateway (BGW) **159**;

(b) the GGSN routes the appropriate packets received from a mobile client to the appropriate CT of his/her corporation; and

c) the GGSN **158** may send, via the same CT **162**, packets originating from users that belong to the same corporation that are received via the same BS **130** or a different BS.

The GGSN **158** performs the following tasks in the downlink direction:

(a) the GGSN **158** terminates the CT **162** and forwards the packets over the GTP tunnels to the appropriate SGSN **152**;

(b) the GGSN **158** receives via the same tunnel **162**, packets with destination addresses of clients, who are currently connected to different BSs **130**; and

(c) the GGSN **158** routes the packets via the appropriate GTP tunnels to the appropriate SGSN **152**.

From GGSN **158,** the CT **162** are transferred via the Border Gateway (BGW) **159** that routes each CT to the appropriate corporation. The terms BGW and the Border Router may be used interchangeably throughout this description.

As illustrated in Fig. 1b, two users **(110B2** and **110B7)** associated with Corporation B, **170b,** and one user **(110A3)** associated with Corporation A **170a** are connected via BSa **130a,** VWB **140a** and SGSNa **152a,** to the operator's premises **150.** Please note that the identification numbers for the users utilize a letter (i.e. 'A' & 'C') to indicate the corporation that they are associated with, and a digit (i.e., 1-7) to indicate the private IP address of the remote client. Two users having the same private IP address (No. 5, **110A5** and **110C5),** are connected via BSn **130n,** VWB **140n** and SGSNk **152k** to the operator's premises **150.** However each of these two users is associated with a different corporation, Corporation A and Corporation C, respectively. Although in Fig. 1b, each SGSN **152** is connected to a single BS **130,** each SGSN **152** may be connected to a plurality of BSs **130.**

From SGSN **152** to GGSN **158** the data travels via GTP tunnel **154.** Each such tunnel may carry data of different users and different BSs **130.** The GGSN **158** terminates the GTP tunnels **154** and generates CTs **162.** Thus, a CT is generated for each corporation (tunnels **162a, 162b** and **162c** connecting to corporation **170a, 170b** and **170c,** respectively). The transportation between user **110A3** and corporation **170a** is done via: BS a **130a,** VWB **140a,** SGSNa **152a,** GTP tunnel **154a,** GGSN **158** and CT **162a** via BGW **159.** The transportation between user **110A5** and corporation **170a** is done via: BSa **130n,** VWB **140n,** SGSNk **152k,** GTP tunnel **154k,** GGSN **158** and CT **162a,** BGW **159.** etc. This present configuration of transportation paths is a momentary situation and can change as the user moves from one cell to the other.

Traffic from a cellular user that is not associated with any of the corporations is transported via the BS **130,** VWB **140,** SGSN **152,** GGSN **158** and BGW **159** to the Internet via a common IP connection, like but not limited to, TCP, UDP etc., to its final destination and not via a CT.

Fig. 2 is a block diagram illustrating the employment of modification equipment within the network topology embodiment provided in Fig. 1a. In general, Fig. 2

illustrates the communication between remote users with their plane destination. The remote terminals **1110a** to **1110n** may belong to mobile peers that communicate with their corporations (**1170a** to **1170k**) via system **200** or private remote terminals **1115** that communicate with public web sites **1180**. System **200** employs the use of a Manipulation Equipment Farm **210** (MEq) that is operating in accordance with an exemplary embodiment of the present invention.

An exemplary embodiment of the MEq **210** intercepts traffic being communicated between the operator premises **1150** and a corporation **1170**. The MEq **210** receives all the packets that are flowing between the Access Provider Network **1150** via AGW **1158** and the BGW **1159** to the Internet **1160** and to corporate intranets **1170**. In one exemplary embodiment, the MEq **210** may be configured as the default gateway for both sides of the Access Provider Network **1150**, (i.e., for AGW **1158** and for the BGW **1159**). In another exemplary embodiment, the MEq **210** may physically reside between the AGW **1158** and the BGW **1159**. In both cases, the MEq **210** may be transparent to both sides of the NBT **1162** or to the IP connection **1182**.
Other exemplary embodiments may use the IP address of the MEq **210** as the next hop address of the AGW **1158** (GRE Proxy). In such an embodiment, the MEq **210** terminates the NBT for both sides, for AGW **1158** and for the corporate intranet **1170**. The destination address of the packets from AGW **1158** to the corporate intranet **1170** is the IP address of the MEq **210** and the source IP address of the packets from the MEq **210** to the corporation is the IP address of the MEq **210**.

Fig. 3 is a block diagram of an exemplary MEq Farm **210** that could be employed in the exemplary embodiment illustrated in Fig. 2. The MEq **210** may include, but is not limited to, the following logical modules:

AGW Interface module (AGWIF) **310**,

BGW Interface module (BGWIF) **320**,

MEq Interface and Dispatcher module (MEqIF) **330**, and

a plurality of Virtual MEq Servers (VMEqS) **350a** to **350n**.

Other embodiments may have other combinations of modules. For example, in one embodiment, the MEq Interface and Dispatcher module (MEqIF) **330** may be divided

into two logical modules: MEq Interface module and Dispatcher module. Each logical module within the MEq **210** may be a software module or hardware module. All the modules may reside in one logical entity or may be spread over several logical entities that are connected over a LAN or by some other means. A logical entity may be a computer. The number of computers employed depends, at least in part, on the traffic at the operator's premises **1150**. The system is scalable and may be upgraded when needed.

The MEq **210** can be viewed as having two major modules or module groupings. These major modules include the Interface module (IF module) **303** and the MEq Server module **307**. Each of these major modules may reside in a different computer or in more than one computer. In addition, each major module may be manufactured by different or multiple vendors. The operation of an exemplary MEq **210** is disclosed below in reference with the direction of the packets.

Uplink Operation

Following is a description of the operation of an exemplary MEq **210** in uplink operation. In the uplink direction, all of the traffic from AGW **1158** (Fig. 2) to the Internet **1160** (Fig. 2) reaches MEq **210** as disclosed above in conjunction with Fig. 2. Traffic arriving at the MEq **210** via connection **215** first arrives at the AGWIF **310** Logical module. Among other things, the AGWIF **310** may check the encapsulation IP header (the header of the NBT packet) of each received packet to determine whether the packet belongs to a corporate intranet **1170** that is a user of the MEq **210**. If the AGWIF **310** determines that a packet belongs to such a corporate intranet **1170**, the AGWIF **310** transfers the packet over connection **313** to the MEqIF logical module **330** for manipulation. However, if the AGWIF **310** determines that the packet does not belong to a corporate intranet **1170** that is a user of the MEq **210**, then the AGWIF **310** transfers the packet, as is, over connection **317** to the BGWIF logical module **320**.

It should be noted that the operation of the AGWIF **310** depends on the topology of the MEq **210**. If the topology is transparent, the source address of each received packet is the IP address of the AGW **1158** (Fig. 2) and the destination address is the address of

the intended corporate intranet **1170**, or any other destination address. Therefore, in an exemplary embodiment, the AGWIF logical module **310** may have a table of all the corporate intranets **1170** that are users of the MEq **210**. Based on a comparison of the destination address with the contents of this table, the AGWIF **310** determines whether the packet will be transferred to the MEqIF **330** or to the BGWIF **320**.

If the topology of the MEq **210** is such that it is terminating the tunnel, the source address of each received packet is the IP address of AGW **1158** but the destination address is the IP address of MEq **210**. In this embodiment, the AGWIF **310** processes the header of the original packets to determine whether the destination address is the IP address of the MEq **210** or one of the VMEqS **350**.

The tunneling protocol between the operator's premises **1150** and the corporate intranet **1170** may use an IP over IP protocol (such as RFC 1241 and RFC 1479) or a GRE protocol (such as RFC 1701, RFC 1702 and RFC 2784), an IEEE 802.1Q protocol (such as VLAN Tagging) or any similar protocol.

In other exemplary embodiments that utilize a clientless MEq option, the AGWIF logical module **310** may run an additional filter in the decision of whether to transfer the packet to the MEqIF **330** or the BGWIF **320**. This filter may be based on the type of the packet. For example, if the packet is based on TCP/IP, then the packet may be transferred to the MEqIF **330** although the client doesn't have the client's side of the MEq **210** software. This particular exemplary embodiment is described in detail in conjunction with Fig. 5.

The MEqIF **330** receives packets that may require manipulation by the MEq **210,** over connection **313**. The MEqIF **330** processes the header of the original packet to determine whether the packet requires manipulations of the MEq Module to be conducted by the MEq Server module **307**. This determination may be based, at least in part, on the destination address of the original packet.

If the destination address of the original packet is the IP address of the MEq **210,** which means that the packet is a control packet. For instance, such a packet may be a request from a new remote client to start a new connection using the MEq **210**. Then MEqIF **330** checks whether the corporation to which the new client belongs already has

been assigned to one of the plurality of VMEqS **350**. If so, in one exemplary embodiment, the MEqIF **330** may define a Source Ports Range Numbers (SPRN) associated with the new remote client, and instruct the appropriate VMEqS to use these source port numbers for the manipulated packets - the results of the packets that has have arrived from this new client. The address of the appropriate VMEqS and the SPRN, which defines the connection to the client, may be used later on during reconstructing the NBT between the MEq **210** and the BGW **1159**. After instructing the appropriate VMEqS **350**, the original control packet is transferred to the appropriate VMEqS **350**, over IP connection **355** for further processing. If the corporation doesn't have a valid connection to one of the VMEqS **350**, the MEqIF **330** creates a new instance - a new VMEqS that will be assigned to this corporation. This new VMEqS will have a new private IP. The MEqIF **330** then updates the VMEqS **350** with the SPRN of the new client and transfers the original packet to the new VMEqS **350** while keeping a record of this packet.

If the destination address of the original packet is the IP address of one of the VMEqS **350a-n**, indicating that this packet belongs to an existing connection between the remote client and the MEq **210,** then the original packet is transferred to the appropriate VMEqS **350** over IP connection **355**. The MEqIF **330** keeps a record of this transfer in a cross-reference table. This record is used upon receiving the manipulated packet from the appropriate VMEqS **350a-n**. The packet to be transferred to the appropriate VMEqS **350a-n** has the source IP address of the client and the destination IP address of the appropriate VMEqS **350a-n**. The record in the cross-reference table may include the destination address of the corporation, the IP address of the remote client (which may be a Private IP address of the client in its corporation), the IP address of the appropriate VMEqS **350** and the SPRN that has been assigned to this client in the VMEqS that has been assigned to the appropriate corporation. This data may be used when reconstructing the NBT in both directions.

Alternate exemplary embodiment may use a proprietary protocol over TCP/IP in order to communicate over connection **355,** between the MEqIF **330** and the plurality of VMEqS **350a-n**. In such embodiment the first packet that initiate a connection between

the MEqIF **330** and one of the VMEqS **350a-n** may contain information regarding the NBT that is handled by the VMEqS via this connection.

The access to the cross-reference table may be based on the type of connection **355** between MEqIF **330** and the plurality of VMEqS **350a** to **350n**. For example, an embodiment of the present invention may have a plurality of VMEqS **350a-n**, wherein each VMEqS **350** may serve a corporation and each client of this corporation may receive a different source port range of numbers (SPRN). Therefore, in this exemplary embodiment, the access record in the cross-reference table for packets coming from the VMEqS **350a-n** and being directed towards the BGW **1159**, may be the IP address of the VMEqS **350** and the SPRN. For the responding packets coming from BGWIF **320**, the access record in the cross-reference table for packets may be the IP address of the corporation (which defines the VMEqS) and the destination port number that defines the remote clients, verifying that it belongs to one of the ports in the SPRN that has been assigned to this client.

If the destination address in the original packet is not the IP address of either the MEq **210** or of one of the VMEqS **350a-n**, then the MEqIF **330** transfers the packet over connection **337** to BGWIF **320**. In other exemplary embodiments, which utilize a clientless MEq option, the MEqIF **330** logical module may run an additional filter in the decision of whether to manipulate the packet. This filter may be based on the type of the packet. For example, if the packet is based on TCP/IP, then the packet may be transferred to one of the VMEqS **350**, which handles clientless traffic. A clientless VMEqS may handle traffic from terminals that do not have the MEq client software installed. More information about this method is disclosed below in conjunction with Fig. 5.

The MEqIF **330** receives the manipulated packet from the plurality of VMEqS **350a-n** via IP connection **355**. Each such packet has the source address of the appropriate VMEqS **350a-n** with the source port number being within the range of the SPRN that is associated with the remote client and the destination address of the final entity in the corporation or in the Internet. Upon receiving a manipulated packet, the MEqIF **330** retrieves the appropriate record of this packet from the cross-reference table based, at least in part, on the IP address of the appropriate VMEqS **350a-n** and the SPRN. Based

on this information, the MEqIF **330** restores the NBT header with the source address of the AGW **1158** (Fig. 2) and the destination address of the corporation router or the site in the Internet. The MEqIF module **330** also reconstructs the internal packet and sets the source IP address to the remote client IP address and the destination address to the corporate or the Internet IP address. Then MEqIF **330** transfers the NBT packet over the connection **337** to BGWIF **320**.

Other exemplary embodiment, which may be used in operator premises **1150** (FIG. 2) that is using VLAN TAG (802.1Q) as the NTB protocol, may transfer the TAG information in the first packet of each new connection over communication lines **355** between the MEqIF **330** and the appropriate VMEqS **350**. The MEqIF **330** may keep this information (the TAG) in the cross-reference table as one of index parameters for the entry of this connection in the cross-reference table and uses it to restore the appropriate NBT for the manipulated packets that are received from the appropriate VMEqS **350**.

Internally to the MEq **210**, the BGWIF **320** receives untouched packets via connection **317** from the AGWIF **310** and manipulated packets via connection **337** from the MEqIF **330**. If a packet is received via connection **317**, the BGWIF **320** transfers the packet, as is, without any manipulations, to the BGW **1159** (Fig. 2) through communication path **217**. If the packet has been received via connection **337** from the MEqIF **330** and if the topology of the MEq **310** is of the transparent type, the BGWIF **320** transfers the received packet, as is, to the BGW **1159** over communication path **217**. The source address of such a packet is the AGW and the destination address is the IP address of the router of the corporation.

If the packet has been received via connection **337** from the MEqIF **330** and the topology of the MEq **310** is the terminating topology, the BGWIF **320** changes the address in the header of the NBT packet by changing the source address to the IP address of the MEq **210** and the destination address to the IP address of the corporation router, which has been configured into the BGWIF **320** during the installation procedure.

Downlink Operation

Following is a description of the operation of an exemplary MEq **210** in downlink operation. In the downlink direction, packets received from the Internet **1160**, or directly from a corporation intranet, such as **1170k**, reach the operator's premises **1150** via BGW **1159** (Fig. 2). These packets are transferred to the MEq **210** over communication path **217** and are received by the BGWIF logical module **320**. The BGWIF **320** performs similar task as the AGWIF **310** when it receives packets in that it sorts the received packets into two groups, packets that may be manipulated by the MEq **210** and untouchable packets. The BGWIF **320** checks the encapsulation IP header (the header of the NBT) of each received packet, or the TAG in case that the NBT is based on VLAN TAG (802.1Q), and determines whether it should be manipulated by the MEq **210**. This decision may be based, at least in part, on searching the source address of the NBT packets in the list of the IP addresses of the routers of the corporations that are currently communicating with one of the VMEqS **350**. This search is done in a copy of the updated cross-reference table, which is delivered from the MEqIF **330**.

In alternate exemplary embodiment, in which the communication is based on VLAN TAG, the tag is used in the cross reference table instead of the source address of the NBT packet.

In other exemplary embodiments, the BGWIF **320** may process the header of the original packet and check whether the destination address of the original packet belongs to one of the VMEqS **350**. If so, the BGWIF **320** then transfers the packet over connection **337** to the MEqIF **330**. Otherwise, the BGWIF **320** transfers the packet, as is, over connection **317** to the AGWIF **310**.

In other exemplary embodiments that utilize a clientless MEq option, the MEqIF logical module **330** may run an additional filter in the decision of whether to manipulate the packet. This filter may be based, at least in part, on the type of the packet. For example if the packet is based on TCP/IP, then the packet may be manipulated and therefore it is transferred to a VMEqS that handles clientless traffic.

An exemplary MEqIF **330** may process the header of the original packet. This process may involve checking the destination address and the destination port number. If the destination address is the IP address of one of the plurality of VMEqS **350**, which indicates that this packet belongs to an existing connection between a remote client and the MEq **210**, then the original packet is transferred to the appropriate VMEqS **350** over IP connection **355**. Then the present invention may determine to which SPRN the destination port number fits. The appropriate SPRN indicates which client is the final destination for this packet. The MEqIF **330** keeps a record of this packet in the cross-reference table.

This record includes the IP address of the router of the corporation and the private IP address of the client. This record is used when reconstructing the NBT after the manipulation of the appropriate VMEqS **350a-n**. The packet to be transferred to the appropriate VMEqS **350a-n** has the source IP address of the corporation and the destination IP address of the appropriate VMEqS **350a-n** with the DST (Destination) port number being in the range of the SPRN that is associated with the remote client.

The cross-reference table that the MEqIF **330** keeps may have the IP addresses of all currently operating VMEqS **350**, the IP address of the router of the corporations that are associated with the VMEqS **350**, the IP address (which may also be private addresses) of the remote clients that are associated with said the VMEqS **350** and the SPRN that is associated with said the client.

If the destination address in the original packet is not the IP address of one of the VMEqS **350a-n**, then MEqIF **330** transfers the packet over connection **313** to AGWIF **310**. In other exemplary embodiments, which utilize the clientless MEq option, the MEqIF **330** logical module **310** may apply an additional filter in the decision as to whether or not to manipulate the packet. This filter may be based, at least in part, on the type of the packet. For example, if the packet is based on TCP/IP, then the packet may be transferred to a VMEqS **350** that handles clientless traffic.

The MEqIF **330** receives the manipulated packets from VMEqS **350a-n** via connection **355**. Each packet received has the source address of the appropriate VMEqS

350. The destination address of this packet is the IP address of the remote client, which may be added by the VMEqS **350**.

Other embodiments may use a common source port number in the direction from the VMEqS **350a-n** to the remote clients, since the VMEqS **350** uses the DST address as the IP address of the remote client and the VMEqS **350** private address as indicating the corporation to which the client belongs. These two addresses are sufficient to define the appropriate entry in the cross-reference table for reconstructing the NBT packet.

In other embodiments, in which the VMEqS **350a-n** does not have a unique IP address, the MEqIF **330** may use a mapping table to retunnel the NBT packet. This mapping may be based, at least in part, on the source port numbers. Upon receiving a manipulated packet, the MEqIF **330** retrieves the appropriate record of this packet and restores the header of the NBT packet. In the NBT header, the source IP address is the corporation's router that is associated with the VMEqS **350**, and the destination address is the IP address of AGW **1158**. Then MEqIF **330** transfers the packet over connection **313** to AGWIF **310**.

In alternate exemplary embodiment, in which the NBT connection is based on VLAN TAG, the tag may replace the address of the corporation router in the NBT header.

Internally to the MEq **210**, the AGWIF **310** receives untouched packets from the BGWIF **320** via connection **317** and manipulated packets from the MEqIF **330** via connection **313**. If the packet is received via connection **317**, the AGWIF **310** transfers the packet, as is, over communication path connection **215** to the AGW **1158** (Fig. 2). If the packet has been received via connection **313** and, if the topology is transparent, the AGWIF **310** transfers the received packet, from the MEqIF **330**, as is, to AGW **1158** over communication path connection **215**. The source address of such a packet is the corporation's router and the destination address is the IP address of the AGW **1158**. If the topology is terminating topology, the AGWIF **310** changes the address in the tunnel header so that, the source address is replaced with the IP address of the MEq **210** and the destination address is replaced with the IP address of the AGW **1158**.

In alternate exemplary embodiment, in which the NBT connection is based on VLAN TAG, the tag may replace the address of the corporation router in the NBT header.

An exemplary embodiment of a MEq Server Module **307** may include, but is not limited to, one or more Virtual MEq Servers (VMEqS) **350a** - **350n**. The VMEqSs **350** are created and managed by the MEqIF module **330**. The MEqIF **330** may generate and control a plurality of instances of the VMEqSs **350a** to **350n**. Each such instance acts as a VMEqS that manipulates data communication.

An exemplary MEq server **307** may be from the NettGain Product Family Line, which is sold by Flash Networks. Such a MEq may operate to accelerate the communication, personalize the context, serve as a front end application server, etc. Each VMEqS is a logical entity that may have a private IP address. The MEqIF **330** may assign the private IP address. Each VMEqS **350** may serve a plurality of remote clients that are associated with the same corporation. A unique source port range (SPRN) may be used to represent each remote client, thereby distinguishing the different remote clients of a corporation that are currently communicating with their corporation. The VMEqS **350** may establish a tunnel connection over IP to each of the current remote clients and maintain the connection as long as the communication with the client exists.

In other exemplary embodiments, in which a proprietary protocol is used over connection line **355** (FIG. 3), the functionality of the SPRN may be replaced by a first packet that initiates the connection between MEqIF **330** and the appropriate VMEqS **350** that will be associated with the remote client and its corporation. The first packet may include information regarding this connection. Information that may be used to restore the NBT packet.

In an alternate exemplary embodiment, a permanent VMEqS may be assigned for each one of the corporations that are the users of MEq **210**. Other exemplary embodiments may generate and keep alive a VMEqS for as long as there is at least one remote client that is currently connected to it. The detailed operation of the MEq **210** is described below in conjunction with the flow charts of Fig. 5 and Fig. 6.

Some of the exemplary embodiments may manipulate communication to terminals that do not have client MEq software. These embodiments may have at least one VMEqS that handles clientless traffic. This type of VMEqS may manipulate the data in a way that

it will be transparent to the other side of the communication, although the manipulated packet has less data than the original packet. For example, it may re-compress JPEG files, as it is disclosed in PCT application number PCT/IL02/00052 and has been published on Aug. 01, 2002 having the international publication number WO02/060106, the contents of which is incorporated herein by reference. A variety of accelerating operations and the manipulation methods can be employed by the VMEqS in various embodiments of this invention. And although the present invention concentrates on the methods of breaking, managing and reconstructing a plurality of Compulsory Tunnels in a way that enables data manipulation and acceleration, the present invention should not be limited to the use of any specific accelerating operations or manipulation methods.

Fig. 4 is a block diagram illustrating another exemplary embodiment of an MEq Farm. This embodiment of the MEq Farm **400** is most useful when installed in an operator's premises that have a high transportation of data between the wireless network and the Internet. The AGW **1158** (Fig. 2) is connected to the MEq Farm **400** over LAN **413** and interfaces to one or more IF Module Servers **303a** to **303m** and to a Load Balancer Server (LBS) **410**. The BGW **1159** is connected to the MEq Farm **400** over LAN **416** and also interfaces to the IF Module Servers **303a** to **303m** and to the Load Balancer Server (LBS) **410**. The LBS **410** may be a common LBS that distributes the transportation between the AGW **1158** and the BGW **1159** among the IF Module Servers **303a** to **303m.** One exemplary embodiment of LBS **410** may be a server that distributes the traffic according to the corporations. The LBS **410** may assign a group of corporations to each one of the IF Module Servers **303**. Each one of the IF Module Servers, **303a** to **303m**, manipulates the transportation that has been associated with it as described above in conjunction to Fig. 3 and sends the appropriate packets over LAN **423** to be further processed by additional MEq Server Modules **307a** to **307n**. Another LBS **420** is connected to LAN **423** for distributing the traffic among the additional MEq Server Modules **307**.

An exemplary embodiment of LBS **420** may also be a server that distributes the traffic according to the corporations. The LBS **420** may assign a group of corporations to each of the MEq Server Modules **307**. Other exemplary embodiments may use the

MEqIF module as the LBS **410**. The additional MEq Server Modules **307a** to **307n** manipulate the transportation that has been associated with it as described above in conjunction to Fig. 3 and send back the manipulated packets over LAN **423** to the appropriate IF Server Modules **303a** to **303m**. Each MEq Server Module **307** may comprise a plurality of VMEqS **350**.

Figs. 5a and 5b are flow charts that illustrate an exemplary method that may be used by an IF module **303** for handling packets coming from an AGW. Upon receiving a packet from the AGW **1158**, at step **510**, the IF Server Module **303** checks whether the received packet belongs to a Network Based Tunnel such as a compulsory tunnel. This step is performed by checking whether it the packet is based on NBT Protocols such as "GRE", "IP over IP", VLAN TAG (802.1Q) etc., and thus is an NBT packet. The NBT Protocol is chosen by the Operator. Generally a single type of NBT protocol is used at a certain operator's premises. If the received packet is not an NBT packet, processing continues at point A in Fig. 5b. If the received packet is an NBT packet, at step **512** the original packet, the packet that is encapsulated in the NTB packet, is parsed and at step **514** it is determined whether the original packet is an IP packet. If the original packet is not an IP packet, at step **516** the NTB packet is transferred, as is, to the BGWIF **320** (Fig. 3). Thus, it is evident that this embodiment of the present invention accelerates only original IP packets. Other embodiments of the present invention may accelerate other types of original packets and the present invention should not be limited to an embodiment that only works on original IP packets. After the NBT packet is sent **516** to the BGWIF **320**, and processing is terminated.

If at step **514** it is determined that the original packet is an IP packet, then a decision is made at step **520** whether the Destination Address (DST) is the IP address of the MEq **210** (Figs. 2 & 3). If the DST is not the IP address of the MEq **210**, this indicates that the remote terminal does not have the client version of the manipulating software. However an exemplary embodiment may manipulate part of the clientless transportation, for example, TCP packets may be accelerated. This exemplary embodiment operates to filter this type of transportation by determining whether the original packet is a TCP packet at step **522**. If the packet is a TCP packet, the IF Module

303 assigns an SPRN that is associated with this terminal, then the cross-reference table is updated with the new connection using the IP address of the terminal (it can be the private IP address), the assigned SPRN, the IP address of the corporate intranet and the private IP address of the clientless VMEqS that will handle this connection. Next, the IF Module **303** instructs the appropriate VMEqS regarding the assigned SPRN and at step **528,** forwards the packet to the appropriate clientless VMEqS **350** over connection **355** (Fig. 3). After the packet is forwarded to the appropriate VMEqS **350,** the processing of IF module **303** is terminated.

If at step **522** it is determined that the original packet is not a TCP packet, then at step **526** the NBT packet is forwarded to the BGW **1159** (Fig. 2) via the BGWIF **320** (Fig. 3). This exemplary embodiment of the present invention operates to manipulate only TCP packets; however, those skilled in the art will understand that the present invention could operate to manipulate other types of original packets and the present invention should not be limited to only performing such operations on TCP packets. After the NBT packet is forwarded to the BGW **1159** processing is terminated.

If at step **520** it is determined that the DST address belongs to MEq **210**, a decision is made at step **530** whether the DST address belongs to a VMEqS. If the DST address belongs to a VMEqS, this indicates that the current packet belongs to an existing connection between the remote client and an appropriate VMEqS. Then at step **534**, the IF Module **303** updates the cross-reference table with the new packet and at step **546** it forwards the packet to the appropriate VMEqS **350**, for further processing, using communication lines **355** (Fig. 3). After the packet is forwarded to the appropriate VMEqS **350,** the processing of IF module **303** is terminated.

If at step **530** it is determined that the DST address of the packet is not a privet address of one of the VMEqS, processing continues at step **532** where it determines whether the packet is a request of a remote client to use the manipulation services of MEq **210** (Fig. 2 & 3). If the packet is not such a request, the packet is a control packet and at step **536** the MEq **210** handles the control packet. If the packet is such a request to use the manipulation services, at step **540** it is determined whether the corporation, to which the remote client belongs, is associated with an existing VMEqS **350a-n** (Fig. 3). If the

corporation is associated with an existing VMEqS, at step **544** the IF Module **303** (Fig. 3) defines the SPRN that will be associated with this client and, updates the cross-reference table with the new connection using the IP address of the client (it can be the private IP address), the assigned SPRN, the corporation IP address and the private IP address of the appropriate VMEqS that will handle this connection. At step **546**, the IF Module **303** then operates to instruct the appropriate VMEqS regarding the SPRN and forwards the packet to the appropriate VMEqS **350** over connection **355** (Fig. 3).

If at step **540** it is determined that the corporation does not have a valid VMEqS associated with it, at step **542** the IF Module **303** creates a new instance, or a new VMEqS, and assigns it to the corporation of the new client and continues processing at step **544**.

Other exemplary embodiments may define the connection with a certain remote client in the first packet of the connection with the selected VMEqS **350** over communication **355** instead of using the SPRN.

Alternate exemplary embodiment that is used in networks, in which the NBT is based on VLAN TAG (802.1Q) protocol, the TAG information may be used to define the connection instead of the address of the router of the corporation.

Returning to step **510**, if it is determined that the received packet is not an NBT packet, the present invention continues at point A in Fig. 5b. At step **550** (Fig. 5b), the received packet is examined to determine whether the received packet is an IP packet. If the received packet is not an IP packet, at step **552** the received packet is transferred, as is, to the BGW **1159** (Fig. 2) via the BGWIF **320** (Fig. 3). In an exemplary embodiment of the present invention, only IP packets are manipulated. However, it should be understood that other embodiments may manipulate other types of packets. After forwarding the received packet to the BGWIF, processing is then terminated.

If at step **550** it is determined that the received packet is an IP packet, then at step **560** it is determined whether the Destination Address (DST) is the IP address of one of the VMEqS. If the DST is not the IP address of one of the VMEqSs, the exemplary embodiment continues at step **566** to determine if the received packet is a TCP packet and then may manipulate TCP packets. If the packet is a TCP packet, at step **567** the present

invention operates to assign an SPRN to the communication with this client and update the cross-reference table with the new connection using the IP address of the client, the assigned SPRN, and the private IP address of the clientless VMEqS that will handle this connection. Finally, the IF Module **303** instructs the appropriate VMEqS about the SPRN and forwards the packet to the appropriate clientless VMEqS **350** over connection **355** (Fig. 3). After the packet is forwarded to the appropriate VMEqS **350,** the processing of IF module **303** is terminated. If at step **566** it is determined that the received packet is not a TCP packet, at step **568** the received packet is forwarded, as is, to the BGW **1159** (Fig. 2) via the BGWIF **320** (Fig. 3) and processing is terminated.

If at step **560** it is determined that the DST address is one of the VMEqSs, this is an indication that the current packet belongs to an existing connection between the remote client and the appropriate VMEqS. At step **562,** the IF Module **303** updates the cross-reference table with the new received packet and at step **564,** the IF Module **303** forwards the received packet to the appropriate VMEqS **350** for further processing using communication lines **355** (Fig. 3). After the packet is forwarded to the appropriate VMEqS **350,** the processing of IF module **303** is terminated.

Figs. 6a and 6b are flow diagrams that illustrate an exemplary method that may be used by an IF Module **303** (Fig. 3) for handling packets coming from a BGW. Processing begins at step **605** upon receiving a received packet from the BGW **1159.** At step **610** the IF Module **303** checks whether the received packet belongs to an NBT (such as a compulsory tunnel) packet, by checking whether the received packet is based on NBT Protocols, such as "GRE", IEEE 802.1Q, or "IP over IP", etc. If the received packet is not an NBT packet, processing continues at point A in Fig. 6b. If the received packet is an NBT packet, processing continues at step **612** where the original packet, the packet that is encapsulated in the NBT packet, is parsed. At step **614** it is determined whether the original packet is an IP packet. If the original packet is not an IP packet, processing continues at step **632** where the NBT packet is transferred, as is, to the AGWIF **310** (Fig. 3). The exemplary embodiment only manipulates IP packets; however, it should be understood that in other embodiments, the present invention may operate to manipulate

other types of packets. After forwarding the NBT packet to the AGWIF **310**, processing is terminated.

If at step **614** it is determined that the original packet is an IP packet, then processing continues at step **620** where it is determined whether the original packet is a TCP packet. If the original packet is not a TCP packet, processing continues at step **632** where the NBT packet is transferred to the AGW **1158** (Fig. 2) via AGWIF **310** (Fig. 3). After forwarding the NBT packet to the AGWIF **310**, processing is terminated.

If at step **620** it is determined that the original packet is a TCP packet, then processing continues at step **630** where it is determined whether this connection belongs to one of the VMEqS **350** (Fig. 3) by examining the cross-reference table. If the connection belongs to one of the VMEqSs **350**, this is an indication that the current packet belongs to an existing communication between a remote client and it's corporation via the appropriate VMEqS. Then IF Module **303** proceeds at step **634** to update the cross-reference table with the new packet using the corporate IP address, the client private address (based on the DST ports that indicates the port numbers range that has been assigned to a specific client, which is derived from the SPRN that has been assigned to the remote client) and at step **636** the original packet is forwarded to the appropriate VMEqS **350**, for further processing, using communication lines **355** (Fig. 3). After the original packet is forwarded to the appropriate VMEqS **350**, the processing of IF module **303** is terminated.

Alternate exemplary embodiment, in which the NBT is based on VLAN TAG, the tag information may be used in conjunction with the information that is stored in the cross reference table.

If at step **630** the connection characteristic carried by this packet are not found in the cross reference table then the processing continues at step **632** where the NBT packet is transferred to the AGW **1158** (Fig. 2) via AGWIF **310** (Fig. 3).

Returning to the case in which the received packet is not an NBT packet **610**, the present invention continues to operate at point A in Fig. 6b. At step **650** in Fig. 6b it is determined whether the received packet is an IP packet. If the received packet is not an

IP packet, processing continues at step **668** where the received packet is transferred, as is, to the AGW **1158** (Fig. 2) via the AGWIF **310** (Fig. 3) and processing is terminated.

If at step **650** it is determined that the received packet is an IP packet, processing continues at step **660** where it is determined whether the connection belongs to one of the VMEqS **350**. The decision is based, at least in part, on the cross-reference table. If the connection does not belong to a VMEqS **350**, processing continues at step **668** where the received packet is transferred, as is, to the AGW **1158** (Fig. 2) via the AGWIF **310** (Fig. 3) and processing is terminated.

If at step **660** the connection does belong to a VMEqS, this indicates that the current received packet belongs to an existing communication between the remote client and the appropriate VMEqS. At step **662**, the IF Module **303** updates the cross-reference table with the new received packet and at step **664** it forwards the received packet to the appropriate VMEqS **350** for further processing using communication lines **355** (Fig. 3). After the packet is forwarded to the appropriate VMEqS **350**, the processing of IF module **303** is terminated. Since there are some network security methods that may use the source port number as a filter to remove hostile communication, some embodiments of the present invention may convert the unique port number, which is in the range of the appropriate SPRN, to a common port number. These methods may use a hashing method to generate a table that keeps the parameters of this connection and enables converting the DST port number of the received packets from the corporations before transferring them to the appropriate VMEqS. This conversion and the table may be done and used by the BGWIF logical module **320**.

The present invention is not limited to methods using a unique approach for indicating the remote client, like but not limited to the SPRN method. Other exemplary embodiments of the present invention may use a common TCP or UDP connection over IP communication line **355** between IF module **303** and MEq Server Module **307** (Fig. 3). In such embodiments, the VMEqS may declare the remote client IP address each time that it establishes a TCP connection toward the BGW **1159** (Fig. 2). Such an embodiment demands a synchronization between the VMEqS and the IF module. Thus, when a VMEqS intends to initiate a new connection (for example a TCP connection) toward the

BGW **1159**, it first sends information about this connection to the IF Module **303**. This information may include the required parameters to be used in the cross-reference table. For example, the final DST IP number in the corporation, the VMEqS IP address as the source address, the DST port at the corporation and the source port in the VMEqS, which may be a common source port, and the IP address of the remote client that may be its private IP address in the corporation, tag information in case of using VLAN TAG protocol.

Some exemplary embodiments may use a clientless VMEqS for each corporation and one or more clientless VMEqS for remote clients that do not belong to any corporation.

In the description and claims, each of the verbs, "comprise" "include" and "have", and conjugates thereof, are used to indicate that the object or objects of the verb are not necessarily a complete listing of members, components, elements or parts of the subject or subjects of the verb.

The present invention may be implemented by any one of, or any combination of, software, hardware, and/or firmware.

The present invention has been described using detailed descriptions of embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. The described embodiments comprise different features, not all of which are required in all embodiments of the invention. Some embodiments of the present invention utilize only some of the features or possible combinations of the features. Variations of embodiments of the present invention that are described and embodiments of the present invention comprising different combinations of features noted in the described embodiments will occur to persons of skilled in the art. The scope of the invention is limited only by the following claims.

CLAIMS

What is claimed is:

1. A method for manipulating the transportation of packets between a source network and IP based destination network, the method comprising the steps of:

(a) receiving a packet from a source, the received packet being intended for a destination;

(b) parsing the received packet to identify the received packet as a packet that can be manipulated;

(c) updating a cross-reference table, the cross-reference table enabling the reconstruction of a connection to the destination;

(d) manipulating the received packet by sending the received packet to a manipulation module;

(e) reconstructing the connection to the destination for the manipulated packet using the cross-reference table; and

(f) transferring the manipulated packet to the destination,

wherein the received packet and the manipulated packet are transferred over network based tunnels.

2. The method of claim 1, wherein the step of manipulating the received packet comprises modifying the received packet in such a way as to accelerate the communication.

3. The method of claim 1, wherein the IP based data network is the Internet, and the step of parsing the received packet further comprise examining the destination and source addresses of the received packet.

4. The method of claim 1, wherein the network based tunnels may implemented using a protocol that belongs to a group of protocols comprising: GRE, IP over IP, IEEE 802.1Q (VLAN Tagging) and the step of transferring the manipulated packet comprises transferring the manipulated packet over such network based tunnel.

5. The method of claim 1, wherein the step of updating the cross-reference table further comprises using a source port number of the received packet coming from the manipulation module.

6. The method of claim 1, wherein the step of updating the cross-reference table further comprises using the IP address of the manipulation module.

7. The method of claim 1, wherein the step of updating the cross-reference table further comprises using the IP address of the destination.

8. The method of claim 1, wherein the step of updating the cross-reference table further comprises using the IP address of the source.

9. The method of claim 1, wherein the manipulation module comprises a plurality of virtual manipulation servers with each virtual manipulation server being dedicated to a particular destination, and the step of manipulating the received packet further comprises sending the received packet to an appropriate virtual manipulation server.

10. The method of claim 1, further comprising the step of parsing the received packet to identify the received packet as a packet that cannot be manipulated and forwarding the received packet, as is, toward the destination.

11. A method for manipulating the transportation of original packets transported between at least one remote client via an access network and at least one IP based private data network, wherein the original packets are encapsulated in network based tunnel packets, and wherein the manipulation is done at the access network service provider's premises, the method comprising the steps of:

transferring, at the access network service provider's premises, the transportation between the at least one remote client and the at least one IP based privet data network via a manipulation system;

parsing a received network based tunnel packet to determine if the received network based tunnel packet can be manipulated;

forwarding the received network based tunnel packet, as is, towards a destination if the received network based tunnel packet cannot be manipulated;

if the received network based tunnel packet can be manipulated:

retrieving the original packet out of the network based tunnel packet;

updating a cross-reference table with parameters that associate the original packet with the received network based tunnel packet, the cross-reference table enabling the reconstruction of a manipulated network based tunnel packet that will be transferred to the destination after the manipulation of the received original packet;

manipulating the original received packet;

reconstructing the manipulated network based tunnel packet with the manipulated original received packet; and

transferring the manipulated network based tunnel packet to the destination over network based tunnels.

12. The method of claim 11, wherein the step of manipulating the received packet is for accelerating the communication.

13. The method of claim 11, wherein the step of reconstructing the manipulated network based tunnel packet with the manipulated original received packet using the cross-reference table.

14. The method of claim 11, wherein the communication between the access network and at least one IP based privet data network is via the Internet, and the step of parsing the received network based tunnel packet further comprises examining the destination and source addresses of the received network based tunnel packet.

15. The method of claim 11, wherein the network based tunnels may be implemented using a protocol that belongs to a group of protocols comprising: GRE, IP over IP, IEEE 802.1Q (VLAN Tagging).

16. The method of claim 11, wherein the network based tunnel is a compulsory tunnel.

17. The method of claim 11, wherein the communication between the remote client and the access network service provider's premises is over cellular connection.

18. The method of claim 11, wherein the step of updating the cross-reference table further comprises using parameters, wherein the parameters that are used for comprise a source port number of packets coming from a manipulation module.

19. The method of claim 11, wherein the step of updating the cross-reference table further comprises using parameters, wherein the parameters that are used for updating the cross-reference table comprise the IP address of a manipulation module.

20. The method of claim 11, wherein the step of updating the cross-reference table further comprises using parameters, wherein the parameters that are used for updating the cross-reference table further comprise the IP address of the at least one IP based private data network.

21. The method of claim 11, wherein the step of updating the cross-reference table further comprises using parameters, wherein the parameters that are used for updating the cross-reference table further comprise the IP address of the at least one remote client.

22. The method of claim 11, wherein the manipulation system comprises a plurality of virtual manipulation servers with each virtual manipulation server being dedicated to one IP based private data network, and the step of manipulating the received

original packet further comprises sending the received original packet to an appropriate virtual manipulation server.

23. A system for manipulating the transportation of original packets transported between at least one remote client via an access network and at least one IP based private data network, wherein the original packets are encapsulated in network based tunnel packets, and wherein the system is at the access network service provider's premises, the system comprising:

an access gateway interface module for receiving network based tunnel packets from, and sending network based tunnel packets toward the at least one remote client via an access gateway;

a border gateway interface module for receiving network based tunnel packets from, and sending network based tunnel packets toward the at least one IP based private data network via a border gateway;

a manipulation module for manipulating the original packets that are encapsulated in the network based tunnel packets;

a manipulation equipment interface module, interfacing to the access gateway interface module and the border gateway interface module and the manipulation module and that is operable to receive network based tunnel packets from, and send network based tunnel packets to the access gateway interface and the border gateway interface modules;

the manipulation equipment interface being further operable to manipulate received network based tunnel packets by retrieving an original packet, sending the retrieved original packet to the manipulation module, receiving a manipulated packet that is the result of the manipulation of the original packet, reconstructing the network based tunnel packet by installing the manipulated original packet and forwarding the reconstructed network based tunnel packet to either the access gateway interface or the border gateway interface.

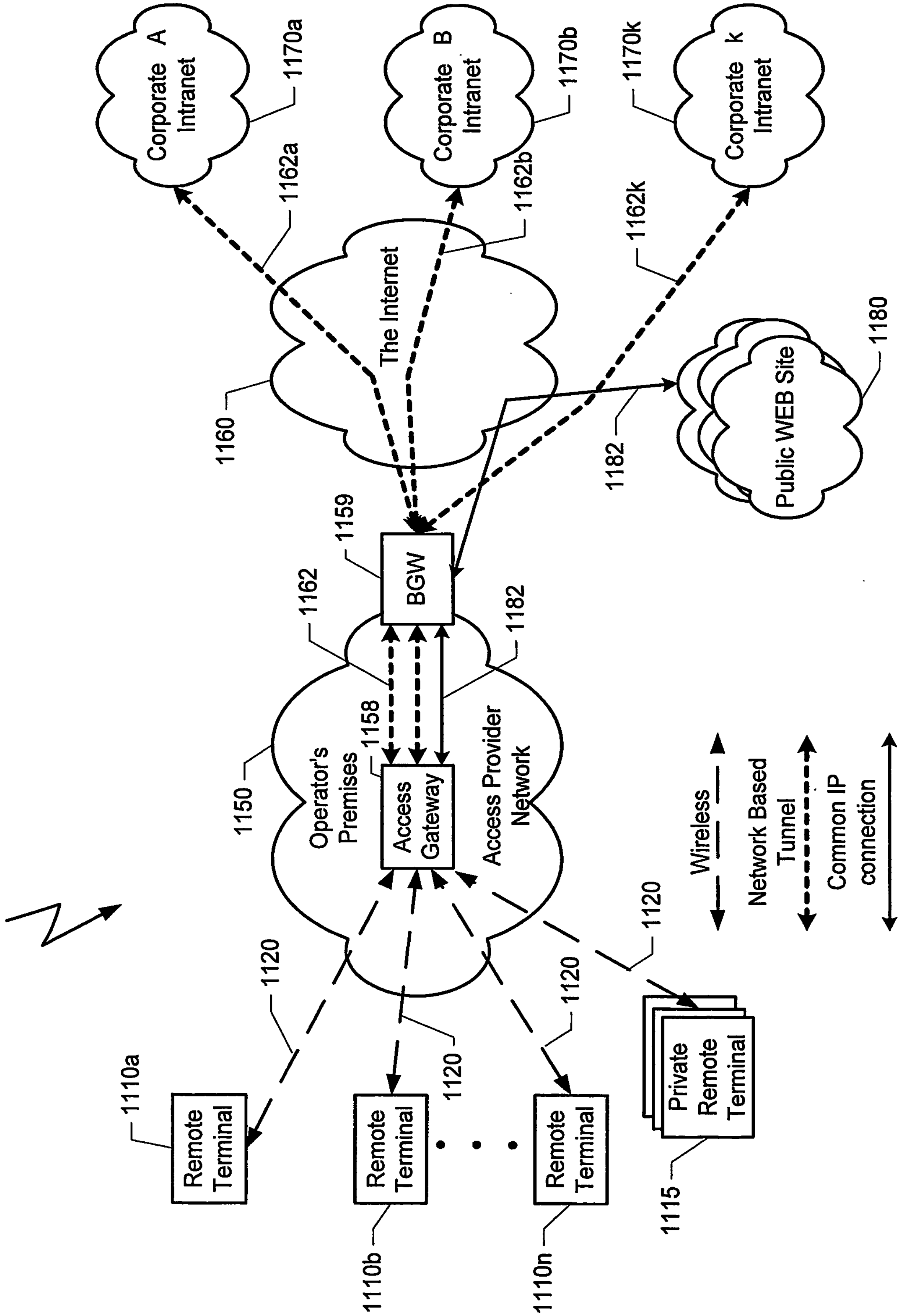
24. The system of claim 23, wherein the network based tunnel may be implemented using a protocol that belongs to a group of protocols comprising: GRE, IP over IP, IEEE 802.1Q (VLAN Tagging).

25. The system of claim 23, wherein the manipulation module further comprises a plurality of virtual manipulation servers, wherein each virtual manipulation server is dedicated to processing traffic for one IP based private data network.

26. The system of claim 23, wherein the manipulation module further comprises a plurality of virtual manipulation servers that are automatically initiated.

27. The system of claim 23, wherein the access gateway interface module maintains a table of all destinations that are users of the manipulation equipment.

Fig. 1a


1100
Remote Terminal
1110a
Remote Terminal
1110b
Remote Terminal
1110n
Private Remote Terminal
1115
1120
Operator's Premises
Access Gateway
1158
Access Provider Network
1150
1162
1182
BGW
1159
The Internet
1160
1162a
1162b
1162k
Corporate A Intranet
1170a
Corporate B Intranet
1170b
Corporate k Intranet
1170k
Public WEB Site
1180
1182
Wireless
Network Based Tunnel
Common IP connection

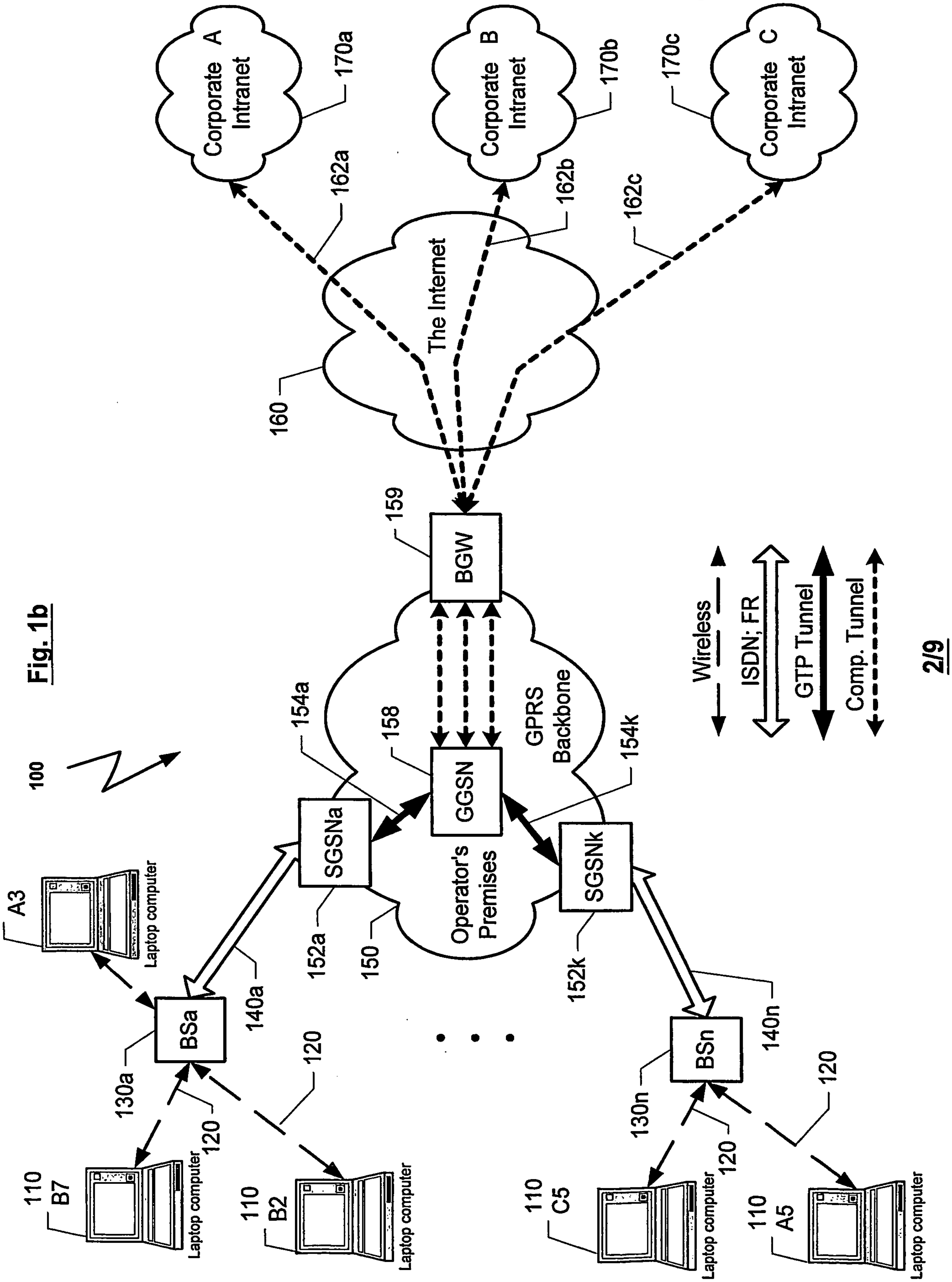

100
Corporate A Intranet
170a
Corporate B Intranet
170b
Corporate C Intranet
170c
162a
162b
162c
The Internet
160
BGW
159
GGSN
158
GPRS Backbone
154a
154k
SGSNa
152a
SGSNk
152k
Operator's Premises
150
140a
140n
BSa
130a
BSn
130n
120
110
A3
B7
B2
C5
A5
Laptop computer
Wireless
ISDN; FR
GTP Tunnel
Comp. Tunnel

Fig. 1b

200

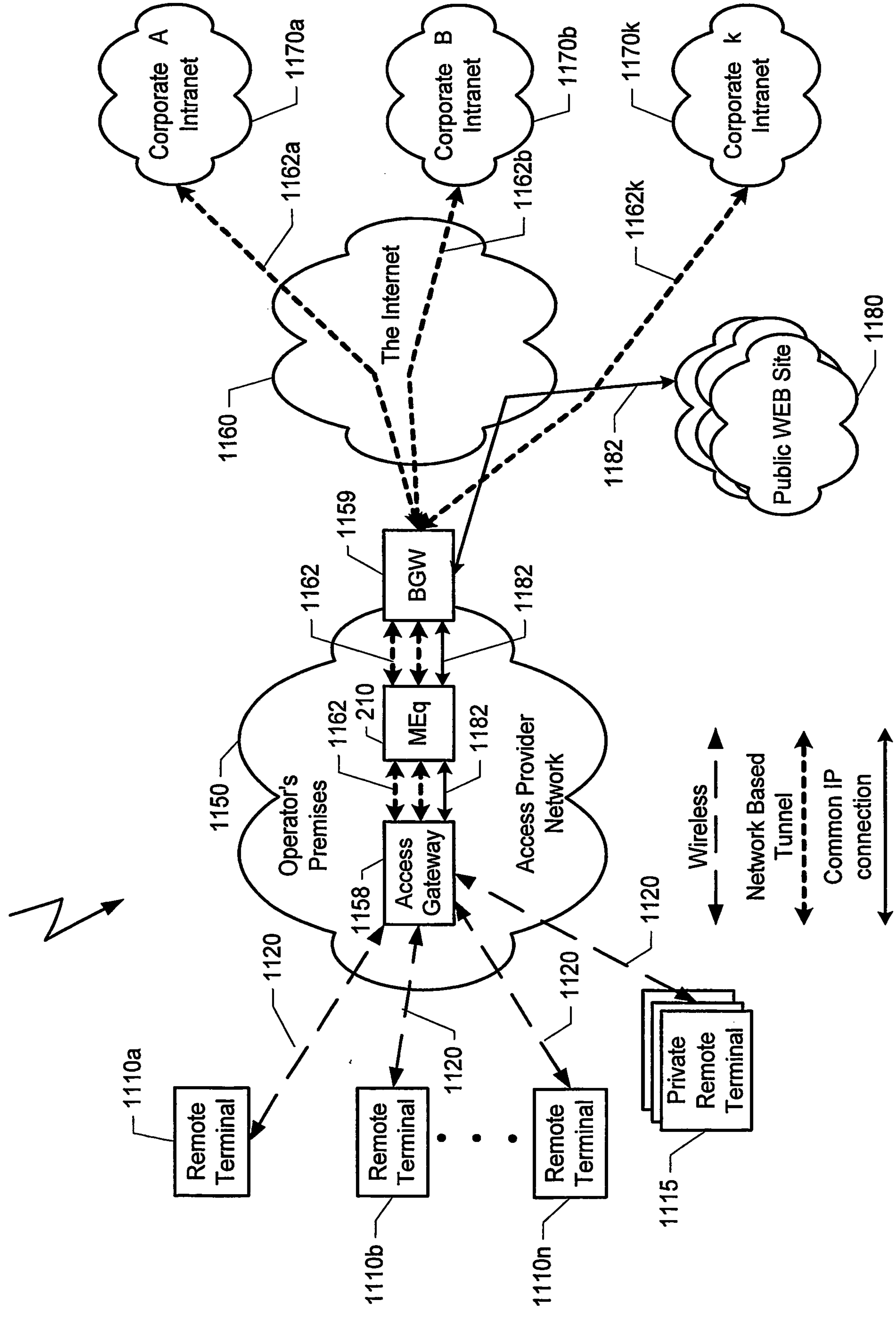

Remote Terminal
1110a
Remote Terminal
1110b
Remote Terminal
1110n
Private Remote Terminal
1115
1120
1120
1120
1120
1120
Access Gateway
1158
Operator's Premises
Access Provider Network
1150
MEq
210
1162
1182
1162
1182
BGW
1159
1160
The Internet
1162a
1162b
1162k
Corporate A Intranet
1170a
Corporate B Intranet
1170b
Corporate k Intranet
1170k
1182
Public WEB Site
1180
Wireless
Network Based Tunnel
Common IP connection

Fig. 2

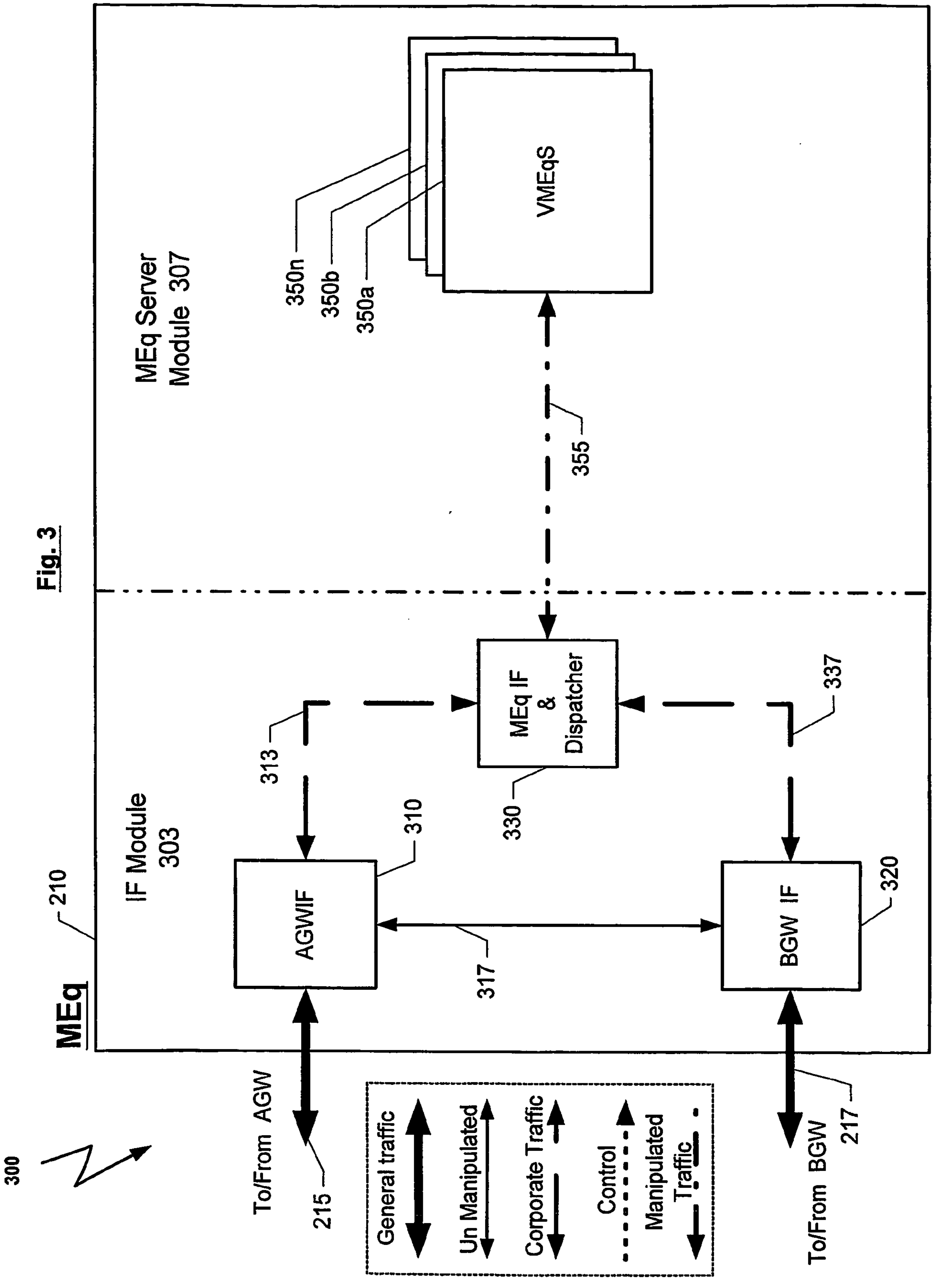

MEq
210
IF Module 303
MEq Server Module 307
AGWIF
310
BGW IF
320
317
313
MEq IF & Dispatcher
330
337
355
VMEqS
350n
350b
350a
300
To/From AGW
215
To/From BGW
217
General traffic
Un Manipulated
Corporate Traffic
Control
Manipulated Traffic

Fig. 3

Fig. 4

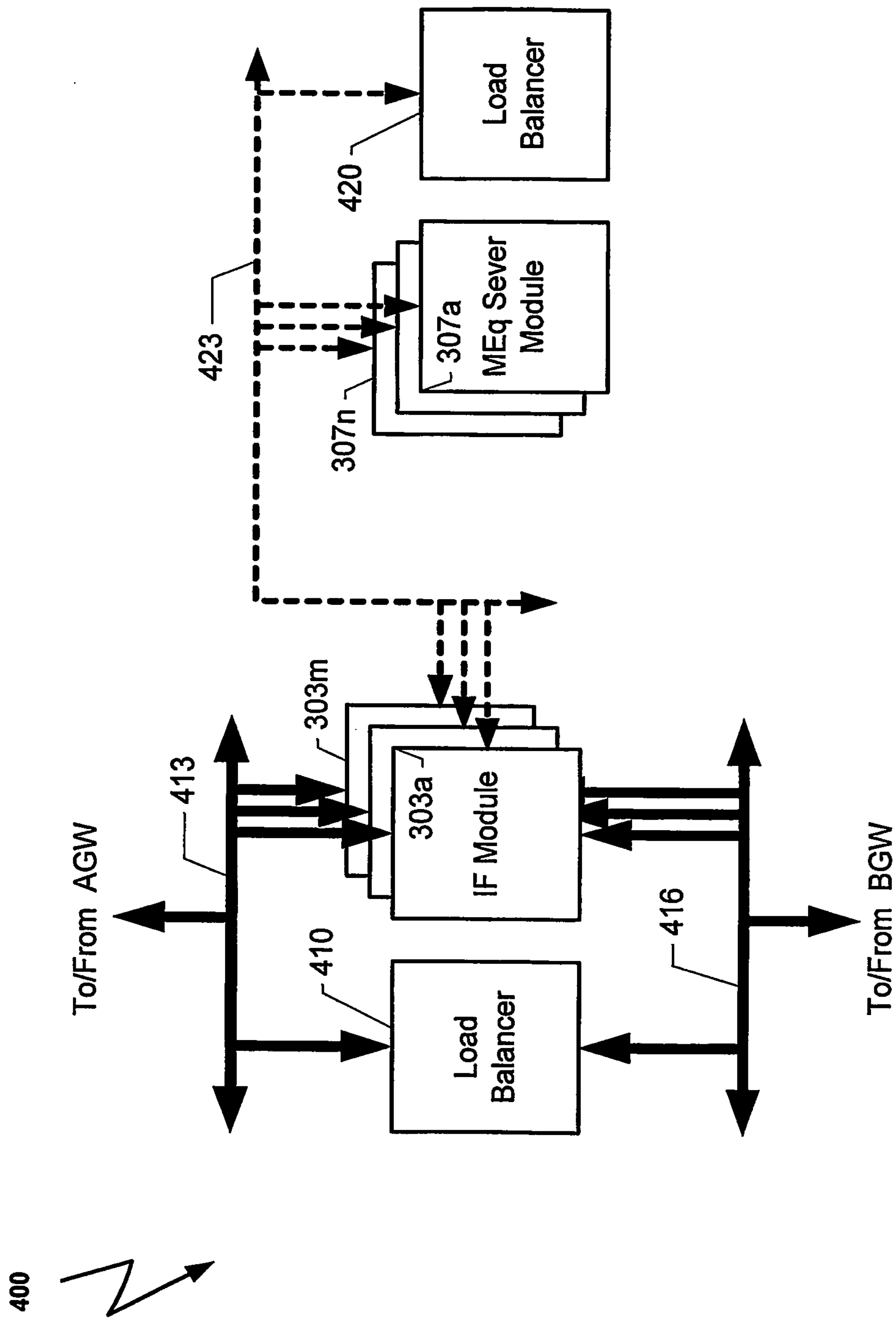

400
To/From AGW
413
410
Load Balancer
303m
303a
IF Module
416
To/From BGW
423
307n
307a
MEq Sever Module
420
Load Balancer

Fig. 5a

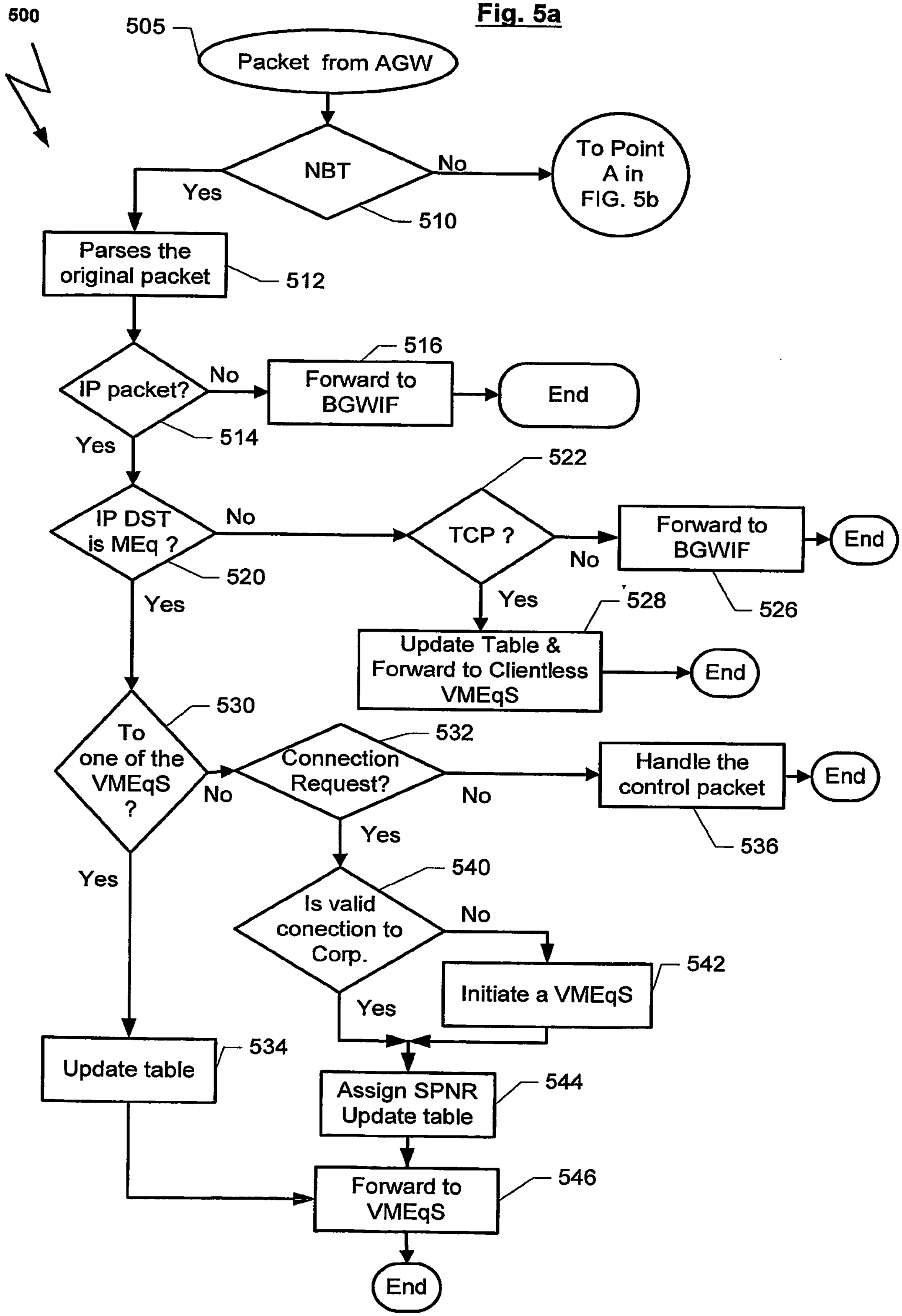
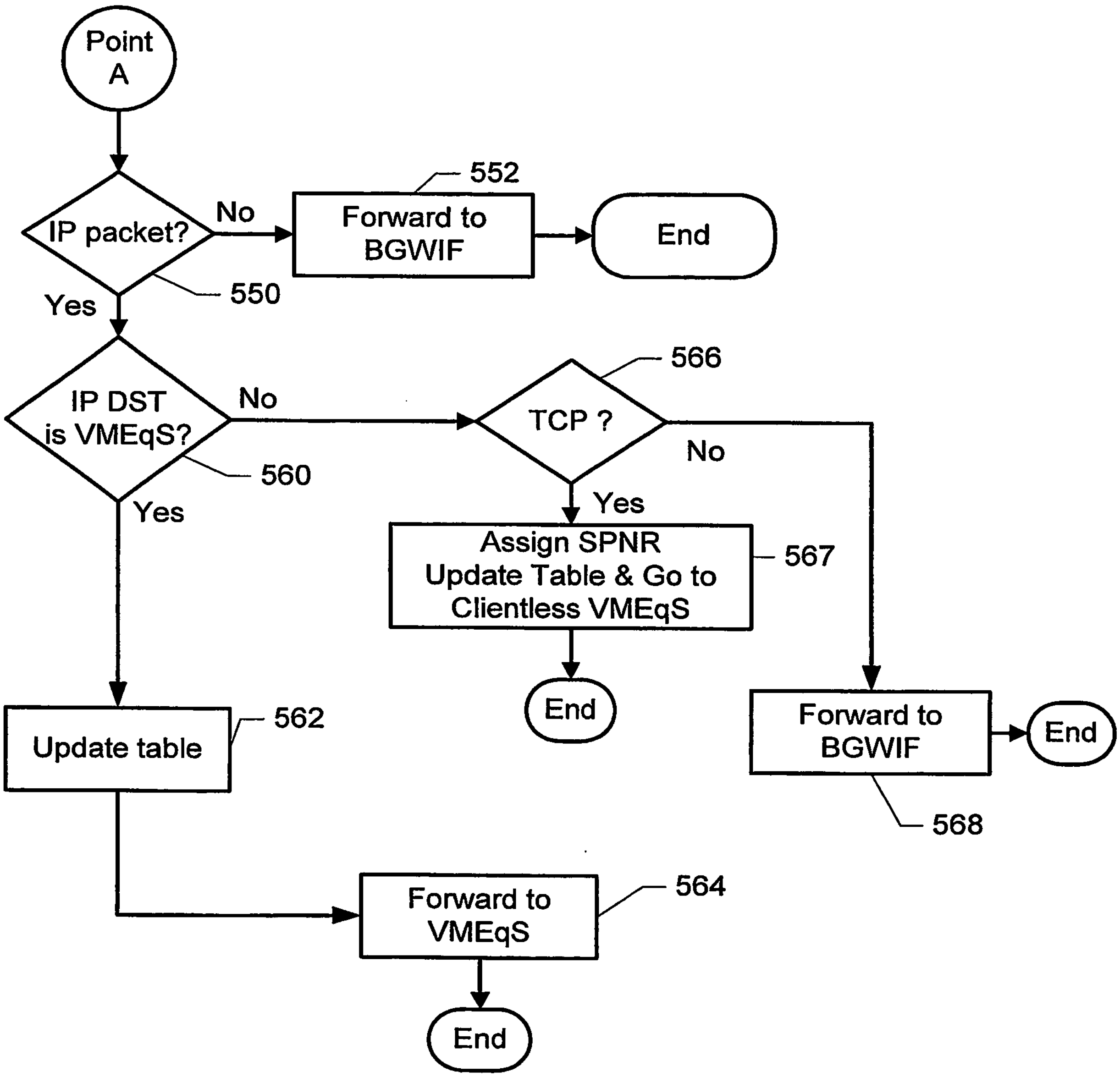

500
505
Packet from AGW
NBT
No
Yes
510
To Point A in FIG. 5b
Parses the original packet
512
IP packet?
No
516
Forward to BGWIF
End
514
Yes
IP DST is MEq ?
No
520
TCP ?
522
No
Forward to BGWIF
End
526
Yes
528
Update Table & Forward to Clientless VMEqS
End
Yes
530
To one of the VMEqS ?
No
Connection Request?
532
No
Handle the control packet
End
536
Yes
540
Is valid conection to Corp.
No
542
Initiate a VMEqS
Yes
Yes
Update table
534
Assign SPNR Update table
544
Forward to VMEqS
546
End

Fig. 5b



Point A
IP packet?
No
Forward to BGWIF
552
End
Yes
550
IP DST is VMEqS?
No
TCP ?
566
No
560
Yes
Yes
Assign SPNR Update Table & Go to Clientless VMEqS
567
End
Update table
562
Forward to BGWIF
End
568
Forward to VMEqS
564
End

Fig. 6a

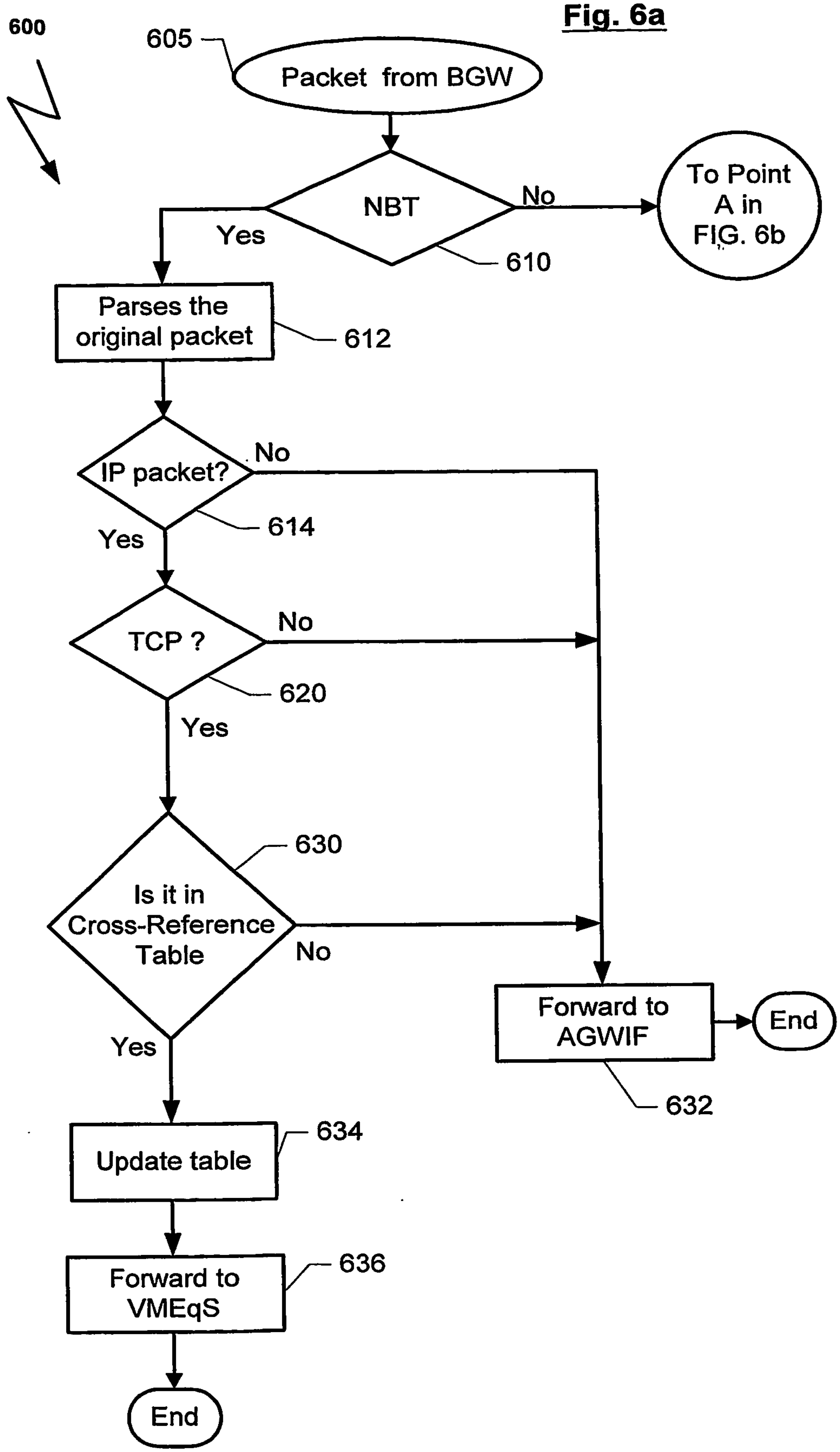
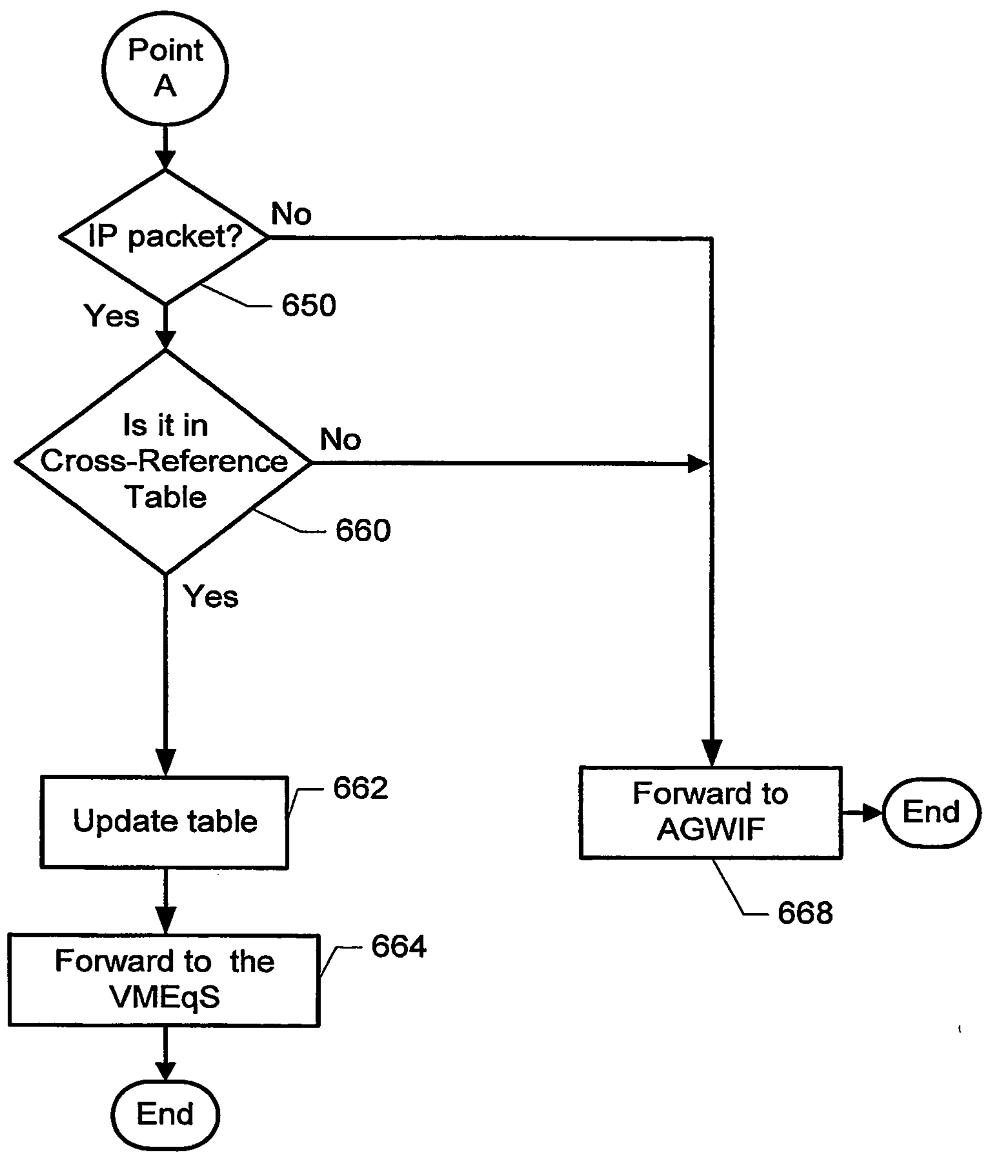

600
605
Packet from BGW
NBT
No
Yes
610
To Point A in FIG. 6b
Parses the original packet
612
IP packet?
No
614
Yes
TCP ?
No
620
Yes
630
Is it in Cross-Reference Table
No
Yes
Forward to AGWIF
End
632
Update table
634
Forward to VMEqS
636
End

Fig. 6b


Point A
IP packet?
No
Yes
650
Is it in Cross-Reference Table
No
660
Yes
Update table
662
Forward to the VMEqS
664
End
Forward to AGWIF
End
668

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL03/00491

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04L 12/56
US CL : 370/351-354,389,392,400,401,428,465,475

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 370/351-354,389,392,400,401,428,465,475

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2001/0044842 A1 (KAWAKAMI) 22 November 2001 (22.11.2001), figure 1, pages 4-5.	1-27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2003 (28.09.2003)	23 OCT 2003

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